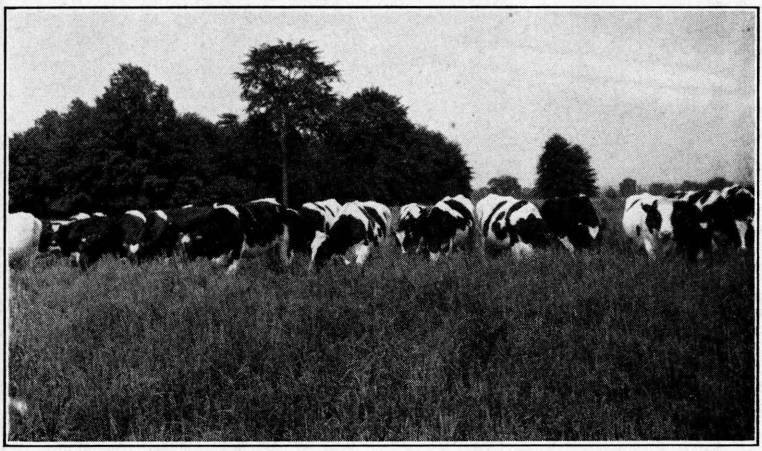
BULLETIN 662 AUGUST, 1946

Dairy Farming Based on the Liberal Use of Meadow Crops



Knee deep in a mixture of alfalfa and timothy.

OHIO
AGRICULTURAL EXPERIMENT STATION
Wooster, Ohio

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DAIRY FARMING BASED ON THE LIBERAL USE OF MEADOW CROPS

PART I

PRODUCING MEADOW CROPS FOR DAIRY FEED

MYRON A. BACHTELL, C. J. WILLARD, AND WALTER LIVEZEY

PART II

MILK PRODUCTION RESULTS

C. F. MONROE AND WALTER LIVEZEY

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CONTENTS

SUMMARY OF PART I,[1] BULLETIN 538, "ALFALFA-TIMOTHY HAY FOR THE DAIRY FARM"

1. In contrast to the corn belt where a considerable part of the tillable acreage is kept in corn and small grains, Trumbull County keeps one-half or more of its land in meadows.

2. At the Trumbull County Experiment Farm a satisfactory system has been worked out which permits one-half or more of the tillable area to remain in meadows.

3. The single, most important factor in securing such meadows has been limestone used in sufficient quantity to bring the soil to a pH of at least 6.0.

4. Meadows averaging 3½ tons or more of high-grade dairy hay have been grown in a small way since 1927 and in an extensive way since 1930.

5. Compared with a 3-year rotation of corn, oats, and hay, an equal area in such meadows has required less man labor, has entailed less cost per acre, and has produced more digestible feed nutrients at a lower unit cost.

6. A very satisfactory seed mixture has been composed of alsike 2 pounds, red clover 4 pounds, alfalfa 6 pounds, and timothy 4 pounds. Reduction or even elimination of the red clover apparently has not materially affected the outcome.

7. At the Trumbull Farm wheat has been distinctly less favorable than oats as a companion seeding crop when the seed mixture has been sown broadcast. This difference between wheat and oats is less marked on some other soils of the State.

8. One 8-acre field over a period of 3 years produced a total of nearly 12 tons of hay per acre with an estimated proportion of 17 per cent clover, 70 per cent alfalfa, and 13 per cent early-cut timothy. Another 5-acre field in 2 years produced over 9 tons per acre with 18, 46, and 36 per cent, respectively, of clover, alfalfa, and early-cut timothy.

9. Alfalfa-timothy meadows cut before the middle of June yield heavy crops of hay which may contain approximately as high a percentage of protein as some commercial, shipped-in alfalfa.

10. Meadows, largely clover for the first cutting of the first year, a mixture of alfalfa and timothy for the first cutting of following years, and alfalfa for the second cutting of all years, constitute the basis of this system.

11. Alfalfa-timothy meadows are drouth-resistant. In both 1930 and 1934 they made very creditable yields when first-year meadows were near failures.

12. As measured by laboratory tests it requires 3 tons of limestone per acre to raise this soil to a pH of 6, with another 1½ tons needed to reach a pH of 6.5. Excellent hay crops have been grown at the lower pH.

13. Other fertility practices have been normal. The dairy herd has produced manure for top-dressing every second year. Superphosphate has been applied at seeding time, but due to financial conditions this sometimes has been considerably below 200 pounds per acre.

14. The alfalfa probably does somewhat better over the tile, but on well-limed fields it is sufficiently good between the lines to produce excellent hay and often it is impossible to detect any difference.

15. Judging from the results at the Trumbull Farm the question "Can one afford to do it?" becomes "Can one afford **not** to do it?"

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[1]Bachtell, M. A., and Harold Allen. Growing High Grade Hay in Liberal Amounts. Published by the Ohio Agricultural Experiment Station in 1934.

PART I. PRODUCING MEADOW CROPS FOR DAIRY FEED

MYRON A. BACHTELL, C. J. WILLARD, AND WALTER LIVEZEY

INTRODUCTION

In August 1934, the Ohio Agricultural Experiment Station published bulletin 538, "Alfalfa-Timothy Hay for the Dairy Farm." The summary of Part I of that bulletin is reprinted in its entirety on the opposite page. The present bulletin is a further report on the use of meadow acreage in dairying at the Trumbull County Experiment Farm.

Dairying is one of the intensive types of livestock farming practiced in Ohio. More gross income can be secured per animal unit or per acre from dairy cattle than from most other types of livestock; for this reason, more labor is required by the dairyman. When labor is mentioned in connection with dairy farming, one instinctively thinks first of the work of milking the cows and cleaning the stable. Feed production is probably considered as something apart, because the labor is very much the same regardless of the type of livestock kept. However, an increased use of meadow crops offers dairymen an ease in their labor load. This is possible because increased meadow acreage probably will reduce grain acreage and the harvesting of meadow crops requires less labor than the harvesting of grain.

MEADOWS EMPHASIZED RATHER THAN GRAIN CROPS

Meadow crops are considered the most important crops at the Trumbull County Experiment Farm; and, therefore, the meadows now occupy over one-half of the tillable area. Previous to 1930, crop acreage was divided rather evenly among corn, oats, and meadow crops, although frequently a few acres were given over to soybeans or Sudan grass if the feed situation warranted it. Some liming had been done; nevertheless, the Experiment Farm was in many respects in the position indicated by a Trumbull County farmer who said, "We always have a feed problem." The hay mow never was full, pastures were inadequate, and grain bills were high—even some hay occasionally was purchased.

About 1930 the trend started toward leaving the meadows down for a longer period than 1 year. In order to secure the type of meadows that would remain productive for 2 or more years, it was necessary to apply sufficient limestone to meet the requirements of alfalfa which was being added to the previous mixture of clover and timothy. This heavier liming has made it possible, in later years, to secure average yields of over 2½ tons of hay per acre from first-year meadows and better than 3½ tons from second-year meadows. Individual years have had yields totaling 5 tons per acre of really good hay.

The full import of the possibilities which this opens to dairymen, perhaps can be expressed best by taking the 76 acres of tillable land on the Trumbull Farm as an example. One-third of this, or 25 acres, in first-year meadow would provide an average of slightly over 60 tons of hay; whereas, 19 acres of first-year meadow and 19 acres of second-year meadow could provide a total in

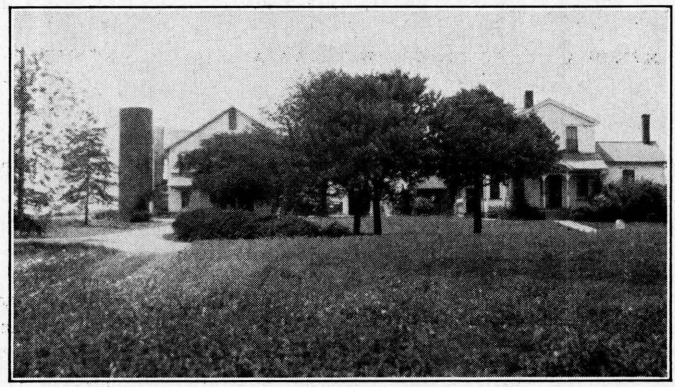

Fig. 1.—At the Trumbull County Experiment Farm the meadow acreage provides the greatest contribution to a satisfactory system of dairying.

excess of 100 tons. As a matter of fact, the Farm at one time produced this larger amount in each of 2 consecutive years. However, since this was a burdensome amount of hay for this size farm, it led to the practice of harvesting a part of each year's hay acreage as pasture—a practice which has proved to be very satisfactory. Standing out above all else is the fact that on this increased meadow acreage a large amount of extra feed is being produced at very little cost.

SIMPLE FERTILITY PROGRAM PRODUCES GOOD MEADOWS

A study of table 1 shows that at the Trumbull County Experiment Farm limestone has made the difference between a total meadow failure on plot 28 and a second-year yield of over 2 tons of hay on plots 1, 4, 7, 10, and 13. None of these plots received any manure or fertilizer. On plot 28 the pH now is 4.5; whereas, on the other five plots it has been raised to nearly 7.0. These latter plots, as a rule, carry a fair stand of alfalfa, but, due to the lack of manure and fertilizer, the plants present do not make sufficient growth to produce a large yield.

Fertility requirements on this soil, aside from limestone, have not been particularly exacting with this type of dairy farming. When worked through the stable, crop yields (such as those given for plot 11 in table 1), result in enough manure to cover one-half the tillable area with approximately 10 tons per acre. Actually, this amount is not produced in the farm program because not all of the crops reach the barn. Because the meadows produce sufficient roughage for feed, all corn stalks stay in the field, except those that go into the silo or those that occasionally are needed for bedding. This permits use of a custom corn picker and thus the tedious job of hand husking is eliminated. Also, part of the hay is consumed as summer pasture and, hence, does not need to be returned as manure hauled from the barn.

Plot 11 has received 19.2 tons of manure per acre per rotation divided between the corn and the first-year meadow. This represents the amount of manure that, theoretically, can be made from the crop yields grown on that

TABLE 1.—The effect of limestone and fertilizer on the yield of crops in a 4-year rotation

Trumbull County Experiment Farm

Rotation: Corn, oats, hay (1), hay (2), 1934 to 1941

Plot	Treatment	Applied on			Average yields			
		Corn	Oats	Hay (1)	Corn*	Oats	Hay (1)†	Hay (2)†
					Bu.	*Bu.*	*Lb.*	*Lb.*
1, 4, 7, 10, and 13	Limestone	.....	.....	.....	48.0	39.0	2,640	4,360
2	Limestone 0-20-0	150 lb.	300 lb.	.....	59.9	50.0	4,010	5.960
3	Limestone 0-20-0	150 lb.	600 lb.	.....	62.4	53.7	4,460	6,390
5	Limestone 0-14-7	150 lb.	300 lb.	.....	62.6	56.2	4,040	5,920
6	Limestone 2-12-6	150 lb.	300 lb.	.....	61.1	53.5	4,100	5,860
8	Limestone Manure 2-12-6	9.2 T. 150 lb.	300 lb.	.....	68.3	56.1	4,970	6,660
9	Limestone Manure 0-20-0	9.1 T. 150 lb.	300 lb.	.....	69.1	56.4	4,700	6,600
11	Limestone Manure 0-20-0	9.6 T. 150 lb.	300 lb.	9.6 T.	70.5	55.6	5,270	7,320
12	Limestone Manure 0-20-0	9.7 T. 150 lb.	600 lb.	9.7 T.	70.0	56.4	5,840	7,120
14	Limestone Manure	7.7 T.	.....	7.7 T.	59.2	44.3	3,680	5,600
26	Manure 0-20-0	8.0 T. 150 lb.	300 lb.	8.0 T.	40.0	45.0	3,200	2,500
28	No limestone No manure No fertilizer	for past 25 years			No corn and oats worth harvesting		Absolute failures	

Notes: Limestone, where applied, was at rate of 2 tons per acre every 4 years.
*Includes drouth-year yields of 1934 and 1941.
†1934 crop disked on account of poor stand and Sudan grass grown. 1940 crop put into silo because it frosted in a very immature stage. Yields would be considerably lower if these two crops were included in average yields.

plot. Plots 8 and 9 receive one-half of the amount that possibly could be made and all is applied on the corn. Yields do not vary greatly regardless of where the manure is applied. In actual field practice on the Experiment Farm the manure is all applied to meadow land with the application made rather lightly so as to cover a maximum acreage. Meadow yields are increased and it is felt that corn yields are practically as good as when some or all of the manure goes on the corn. Moreover, putting the manure on meadows makes it possible to fall plow for next year's corn crop—a practice that is becoming increasingly popular on this farm.

Incidentally, about the only loss in manure value on the Trumbull County Experiment Farm is in the drip of liquid which occurs when hauling the manure from stable to field. Manure is spread on the fields daily as produced with the exception possibly of a dozen loads, which may temporarily be thrown outside the stable during the course of an entire winter.

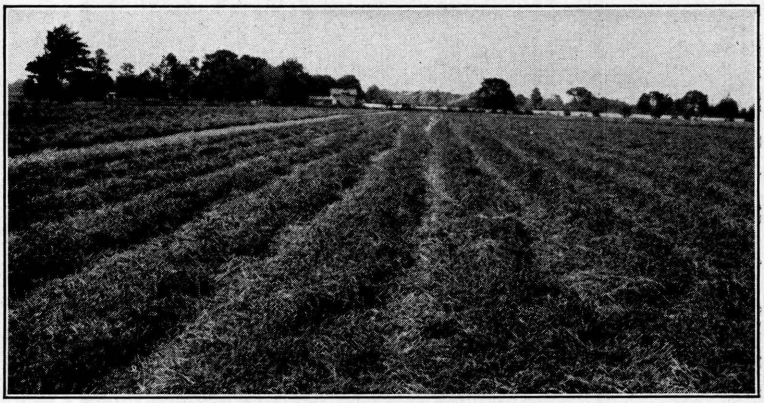

Fig. 2.—Heavy yielding meadows are the basis for economical dairy production.

Fertilizer practice follows the common plan of a hill or row application of complete fertilizer for corn and a fairly liberal application of superphosphate when sowing oats with which the meadow crop is seeded. Thus, the excellent meadow yields that have been secured are produced essentially in a limestone-manure-phosphate system. The soil type is one which releases a considerable amount of potash per year.

MEADOWS MORE RELIABLE THAN CORN

At the Trumbull County Experiment Farm, corn has produced only slightly more feeding nutrients than the second-year meadow which can be grown with much less labor and expense. The data given in table 2 are probably unduly favorable to corn in that the yields of that crop for the unfavorable seasons of 1934 and 1940 are not included in the average yield; whereas, the average yield of hay includes the two drouth years of 1934 and 1941. This is not a good corn section; wet springs delay planting on the heavy clay soil and early frosts often make the crop unfit for use other than for ensiling.

TABLE 2.—Crop yields and total digestible nutrients on well limed, fertilized, and manured land

Crop	Trumbull County Experiment Farm, 1934 to 1941 Yield per acre		
	Total production	Total digestible nutrients	
		Lb.	
Ear corn*.....	70.5 bu.	3745	(1934† and 1940‡ crop not included)
Meadows—1st year....	5270 lb.	2710	(Includes drouth yields of 1934 and 1941)
Meadows—2nd year...	7320 lb.	3675	(Includes drouth yields of 1934 and 1941)

*Estimated at 59.1 bushels per acre and 3,140 pounds digestible nutrients if the 1934 and 1940 crops are included at 25 bushels per acre for each of these years.

†In 1934 an exceptionally dry spring caused a poor stand which was disked up and Sudan grass was grown for silo.

‡In 1940 the immature crop was ensiled to the limit of silo capacity, the remainder was shocked, and fed to heifers as chopped fodder.

Exclusion from table 2 of the two unusual corn crops gives an average yield of corn containing 3745 pounds of total digestible nutrients in the ears. This is only 70 pounds more than in the hay from the second-year meadow, even when the meadow yields for 2 drouth years are included in the average. If the 1934 and 1940 corn crops were to be included (each at an estimated 25 bushels per acre) the 8 years' average acre yield of corn would be cut to 59.1 bushels containing only 3140 pounds of digestible nutrients. This is 535 pounds less than the second-year meadow produced.

LARGE PROPORTION OF LAND IN MEADOW INCREASES FEED NUTRIENTS

A very common dairy farm rotation in northern Ohio is corn, oats, wheat, and meadow. This devotes only one-fourth of the tillable land to hay production. This proportion is increased to one-third by a rotation of corn, oats, meadow; and to one-half, if the rotation is lengthened to 4 years by adding a second-year meadow. A 5-year rotation with 3 years of meadow devotes three-fifths of the land to hay and pasture crops.

TABLE 3.—Rotation comparisons at Wooster

Calculations based on 60 acres of tillable land
5-year average yield, 1936-1940

Rotation	Yields* per acre						Per cent of land in meadow	Feed nutrients† from 60 acres
	Corn	Oats	Wheat	Meadows				
				1st	2nd	3rd		
	Bu.	*Bu.*	*Bu.*	*Lb.*	*Lb.*	*Lb.*		*Units*
Corn, oats, wheat, clover..	75.7	64.6	39.4	5300	.....	.....	25	152,000
Corn, wheat, clover.....	74.7	.....	40.6	6070	.....	.....	33⅓	181,000
Corn, wheat, alfalfa, alfalfa.....	77.5	.....	43.0	7790	9470	.....	50	225,000‡
Corn, wheat, alfalfa, alfalfa, alfalfa.....	73.9	.....	42.5	7570	9780	9900	60	237,000

*Data from Agronomy Department, Ohio Agricultural Experiment Station.
†Wheat included in computing feeding nutrients.
‡Estimated to be 216,000, if oats replaced wheat.

The comparative feed production possible from these various rotations is given in table 3. The data indicate the possibility of increasing the total feed nutrients from a given acreage by devoting a greater proportion of land to meadows and thus obtaining the large production that can go with second- and third-year meadows. In the Wooster test, it was possible to increase the production of dairy feed nutrients more than 50 per cent by taking advantage of this one factor.

LESS LABOR, LOWER COST OF FEED NUTRIENTS

Table 4 is adapted from studies made by the Department of Rural Economics and Rural Sociology[2] of the Ohio Agricultural Experiment Station. The figures denoting man hours should be considered only as a rough comparison, since the actual man hours expended on any farm vary greatly, depending

[2]Baker, R. H. 1941. Labor requirements for crop production in Ohio. Ohio Agr. Exp. Sta. Dept. of Rur. Ec. Mimeo. Bull. 115.

on how extensively tractors, corn pickers, combines, buck rakes, and other pieces of equipment are used. At the present time, power equipment is rapidly lowering the man-hour requirements of many operations. Nevertheless, it is possible to make estimates that may indicate quite accurately the relative cost of producing feed nutrients in the different rotations. Two facts stand out: The number of feed nutrients increases with the proportion of land in meadow, and there is a decrease in the cost of growing and harvesting the crops. Based on these two facts, the unit cost of producing feed nutrients for the dairy cow is greatest where only one-fourth of the land is in first-year meadow. There is some decrease in cost when one-third of the land is devoted to first-year meadow, and a considerable decrease when a high-yielding second-year meadow is made a part of the rotation. The additional gain from keeping the meadow a third year is not so great. This economy in producing feed by the legume-grass method should lead dairymen to utilize meadows to the fullest degree possible.

TABLE 4.—Estimated labor requirements and dollar costs of farming 60 acres of tillable land in northeastern Ohio

	Relative man-hours required	Relative cost of	
		Producing crops	Feed nutrients
	Pct.	*Pct.*	*Pct.*
Corn*, oats, wheat, clover	100	100	100
Corn*, wheat, clover	95	95	82
Corn†, wheat, alfalfa‡, alfalfa‡	58	75	51
Corn†, wheat, alfalfa‡, alfalfa‡, alfalfa‡	56	70	46

*Husked from shock with fodder possibly used for feed.
†Picked from stalk: fodder not needed for feed as rotation supplies plenty of hay.
‡Second cutting and perhaps some of first cutting pastured.

The data given in table 4 indicate a considerable saving in field work when a larger part of the tillable area is devoted to meadows. However, since much of the work connected with meadows occurs in harvesting, enlarging the acreage may increase the labor load in June. At the Trumbull Farm, it was found during the '30's that trying to harvest all of the hay from an enlarged meadow acreage tended to defeat the purpose of growing more grass. Constant haymaking became tiresome, particularly after the mows were filled and the overflow had to be stacked. However, pasturing the dairy hard on a part of the first growth and much of the second growth provided a partial solution for this problem. Results in recent years have indicated that this has been a very good practice.

FORTY-ONE DAYS ON BLUEGRASS

Weather records in Trumbull County show that the average length of time between killing frosts is 146 days—from May 12 until October 5. The Experiment Farm, thus, is located in the shortest growing season area of the entire State. Date of turning out to pasture varies from May 3 to May 20. This may seem late, but, as indicated above, this is not an early-season section, the soil does not warm up readily, and grass is slow to start. However, bluegrass may start to head out almost any time during the last 10 days of May. Consequently, an effort is made to clip the permanent pastures before June 1, or as soon thereafter as possible. This practice prolongs the useful period of

bluegrass, but as a rule this source of pasture is limited in both quality and quantity by the middle of June or even sooner. During the two typical seasons of 1939 and 1940, cows on the Trumbull County Experiment Farm relied on bluegrass as their sole source of roughage for an average of only 41 days. At all other times during the pasture season they were on rotated meadows, with access to bluegrass pastures through which they had to pass in order to get to their water supply. Just how much value they secured from bluegrass during this period cannot be determined, but it was noticeable that the cows spent some time grazing the bluegrass every day and kept it fairly well eaten down. This may have no significance, but, on the other hand, it occurred with such regularity that it may indicate that the cows found something in bluegrass which supplemented the alfalfa growing so abundantly on the other side of the fence.

ONE HUNDRED AND (HOW MANY?) DAYS ON ROTATED MEADOWS

The data in table 5 show that meadow yields varied considerably from year to year. It is not surprising, therefore, nor need it be particularly disappointing, to find that the amount of pasture obtained from the meadows also varied to a considerable degree. In 1939, a prolonged dry spell started in late July, and by September 14 grazing material was so scarce in both pastures and meadows that it was considered desirable to start some supplemental hay feeding. In 1940, a dry July was sandwiched between a wet June and a normal August, but no barn feeding was started until October 18. During 1941, April and May were so dry that first-year meadows produced as little as one-half ton of hay per acre. Consequently, it required many acres of both first and second cutting to obtain the winter's supply of hay. Therefore, instead of pasture from rotated meadows all summer, the herd received meadow-crop silage for 5 weeks starting the middle of July. However, this period largely was offset by a month of excellent pasture between September 26 and October 27, which was obtained from a very rapid late summer growth of alfalfa. Partly due to this month of excellent pasture from rotated meadows, the cows went into their winter stalls in higher-than-average production. The dream season, from the dairyman's standpoint, was in 1942 when the cows obtained all of their roughage from bluegrass pastures and rotated meadows from May 3 until October 27, a period totaling 177 days.

Thus, during the above 4-year period there was no rigidly-followed system of summer pasture, and, perhaps, there can be none when so much depends on the weather. In spite of the seasonal uncertainties, it is apparent that in addition to the 41 days on bluegrass there was obtained another one hundred and ten or fifteen days on rotated meadows, plus access to bluegrass pastures. Although there is no measure of comparative feed values which were secured from these two types of pastures during this period, there are plenty of reasons for believing that the rotation meadows provided several times the nutriment that could have been obtained from bluegrass during the long, hot days when bluegrass is likely to be mature and dry. In addition to maintaining heavy summer milk flow, rotation meadows kept the cows in shape for continued high winter production.

APPARENT LOSSES MAY NOT BE SERIOUS

Perfect coordination on a dairy farm so that there always is enough pasture, and never too much, is rarely possible. *A surplus of pasture which is easily visible to the eye often is more disturbing than a slight deficit which may pass unnoticed.* June is most likely to be the time of surplus. With favorable weather, bluegrass and white clover still may be luxuriant when the meadow growth has reached the pasture stage. If the entire meadow growth is needed for hay, no problem is involved. At the Trumbull Farm where the amount of meadow acreage makes it almost mandatory that some of the first cutting be pastured, it is the custom to put an electric fence around part or all of one meadow and turn in the herd any time after June 1. Even if turned in 2 weeks later, when the growth is considerably more mature, it is surprising how well the field is finally cleaned up. However, at this farm it is considered a better practice to maintain milk production by turning on to another succulent meadow, rather than to cause a decrease in milk flow by forcing the animals to clean up too closely all over-ripe growth. Such growth can be cut with a mowing machine and left on the ground or, if needed, it can be raked and stored for bedding. But it always must be kept uppermost in mind that *any apparent loss from a surplus in June is likely to be more than offset by the advantage of having liberal pasturage during the other pasture months.*

ALFALFA HOLDS THE ANSWERS

On well-stocked dairy farms where sufficient meadow acreage can be obtained only by holding the meadows for a second or even a third year, the successful inclusion of alfalfa in the meadow mixture becomes of primary

Fig. 3.—A desirable mixture of alfalfa and timothy.

importance. The amount of July and August pasture is more dependent on alfalfa than on red clover because the latter largely disappears after the first hay-year; whereas alfalfa continues to develop and establish a deep root system which enables it to make some growth even during summer dry periods.

LADINO CLOVER

Ladino clover is similar to alfalfa in that it may stay in meadows for more than one hay-year; it contrasts with alfalfa in that it has a shallow root system and, thus, is not so highly drouth-resistant. It, therefore, can not entirely take the place of alfalfa for midsummer pasture. Because so much depends on having persistent legumes in rotation meadows and since alfalfa is highly vulnerable on the heavy soils of Trumbull County, Ladino clover is being added to the seed mixture as additional legume insurance in case alfalfa is a partial or total failure. One pound of Ladino clover seed now partially replaces the 2 pounds of alsike seed formerly used. In general, the seed mixture now sown on one acre approximates alfalfa, 5 to 6 pounds; red clover, 3 pounds; alsike, 1 pound; Ladino, ½ to 1 pound; and timothy, 6 pounds. On soils where alfalfa is more dependable there is less need for adding Ladino clover to the mixture.

ADDITIONAL INSURANCE

When meadows assume as much importance in the dairy scheme as they do at the Trumbull County Experiment Farm, one can go to considerable effort to assure their success. Thus far, at this farm, reasonable success has been secured by the mere following of what might be considered good agronomic practices. The first consideration is an adequate liming program. Inasmuch as wheat is a minor crop in this section most of the grass seedings are made with oats. Fall plowing of corn-stalk land is preferred. The oat crop is well fertilized and the alfalfa-clover-timothy seed mixture is scattered behind the hoes in an effort to avoid too deep coverage. Cultipacking is practiced if dry weather prevails at seeding time. The degree of success has been fairly satisfactory, although failures have been caused by extremes of weather conditions the first month after seeding, by the lodging of rank-growing oats previous to maturity, and by various forms of winter injury.

Fig. 4.—"Poverty vs. Riches" in Dairy Feed Production
Left—Plot 28—Unlimed, unmanured, unfertilized.
Right—A nearby alfalfa-grass meadow; adequately limed, well manured and moderately fertilized.

Unfortunately, on many soils there is considerable difficulty in securing a good stand of alfalfa in mixed seedings. Apparently such failure is more likely to occur where the seeding is made in wheat, especially if the fertility conditions are such that a thick, heavy growth of straw occurs. On the Trumbull Farm, wheat rarely yields over 30 bushels per acre and many fine seedings are secured by sowing with this crop, especially if the seeding is made in March. Timothy sown on wheat in the fall is surer than on oats in the spring.

A failure to secure a catch of alfalfa when using the mixture leads to complications because red and alsike clovers largely disappear after the first hay-year, thus leaving nothing for succeeding years but timothy, or possibly timothy and Ladino clover, if the latter has been included in the mixture. At the Trumbull Farm it usually has been possible to meet such a condition by switching rotation plans—that is, by plowing the 1-year clover sod for corn and retaining an older alfalfa-timothy meadow which still is good for another year of hay or pasture. Obviously, this solution has its limitations if alfalfa failures come in 2 or more successive years or if farming programs make it necessary to maintain each field or strip in meadow a definite number of years.

Fig. 5.—Perfect mixtures are difficult to secure.
Left—First-year meadow of clover and timothy but lacking sufficient alfalfa to carry on for second- and third-years.
Right—Second-year meadow showing a good stand of alfalfa but not enough grass for a satisfactory mixture.

With second- and even third-year alfalfa-timothy meadows assuming such an important role in the dairy management at the Trumbull County Experiment Farm, it was necessary to consider the effect of cutting dates, not only in regard to quality of hay secured but also in relation to maintenance of the alfalfa stand. The Trumbull Farm is more or less typical of a considerable section in northeastern Ohio where the soil is not well adapted for alfalfa, where growth is slow in spring, where frosts come early in the fall, and where winter heaving can be serious.

Experiments and experience have led to the recommendation of dates of cutting for the different parts of the State, which have proved very satisfactory in practice.[3] [4] For most of Ohio, three cuttings during the season give best results. At Holgate, in northwestern Ohio, two cuttings a year yield less but are more favorable to long-lived stands of alfalfa than three cuttings. Northeastern Ohio has a shorter growing season and soils less well adapted to alfalfa than northwestern Ohio, so it might be expected that two cuttings would be still more favorable to the stand in Trumbull County than at Holgate.

[3]Willard, C. J., L. E. Thatcher, and J. S. Cutler. 1934. Alfalfa in Ohio. Ohio Agr. Exp. Sta. Bull. 540.
[4]Lewis, R. D., J. A. Slipher, and C. J. Willard. 1934. Alfalfa in Ohio farming. The Ohio State Univ. Agr. Ext. Bull. 137.

TABLE 5.—Time of cutting alfalfa-clover-timothy mixtures

Trumbull County Experiment Farm

Plots and systems of cutting	Dates of cutting	Yields per acre in 3 trials of 2 years each												
		Block K			Block 2C			Block OPRS			Average blocks K, 2C, OPRS			
		1st year 1938	2nd year 1939	Total 2 years	1st year 1939	2nd year 1940	Total 2 years	1st year 1941	2nd year 1942	Total 2 years	1st year	2nd year	Total 2 years	Loss or gain in 2nd year versus 1st year meadow
		Lb.	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*
Plots 1 and 6, 3 cuttings each year. 1st one early.	June 1	4,410	2,940		3,280	1,880		960	4,360		2,880	3,060		
	July 15	2,460	1,490		1,210	*		470	1,180		1,380	890		
	Sept. 1	1,980	720		1,250	*		1,930	1,000		1,720	570		
	Total	8,850	5,150	14,000	5,740	1,880	7,620	3,360	6,540	9,900	5,980	4,520	10,500	—1,460
Plots 2 and 7, 2 cuttings 1st year; 3 cuttings 2nd year; 1st one early	June 1	.....	3,350		.....	2,330		.....	4,360		.....	3,350		
	June 15	5,040	.....		6,680	.....		930	.....		4,220	.....		
	July 15	.....	1,820		.....	*		.....	1,940		.....	1,250		
	July 25-30	2,460	.....		2,280	.....		960	.....		1,900	.....		
	Sept. 1	.....	1,660		.....	*		.....	1,430		.....	1,030		
	Total	7,500	6,830	14,330	8,960	2,330	11,290	1,890	7,730	9,620	6,120	5.630	11,750	— 490
Plots 3 and 8 3 cuttings each year	June 15	5,120	6,110		6,940	6,190		900	4,120		4,320	5,470		
	July 25-30	2,450	1,140		2,420	1,550		1,130	2,620		2,000	1,770		
	Sept. 5-10	1,730	620		850	460		1,240	1,420		1,270	830		
	Total	9,300	7,870	17,170	10,210	8,200	18,410	3,270	8,160	11,430	7,590	8,080	15,670	+ 490
Plots 4 and 9 2 cuttings each year	June 15	4,750	5,360		6,140	5,070		920	3,580		3,940	4,740		
	July 25-30	2,300	1,560		2,200	1,860		1,070	3,550		1,850	2,320		
	Total	7,050	7,120	14,170	8,340	6,930	15,270	1,990	7,130	9,120	5,790	7,060	12,850	+1,270
		Rainfall												
		In.	*In.*		*In.*	*In.*		*In.*	*In.*					
April		3.69	4.44		4.44	4.93		1.30	3.35					
May		3.29	1.14		1.14	4.71		1.83	6.92					
June		3.33	5.08		5.08	5.85		3.10	4.48					
July		3.77	5.82		5.82	1.50		3.91	4.09					
August		2.32	1.33		1.33	3.29		4.08	2.10					
Total		16.40	17.81		17.81	20.28		14.22	20.94					

*Not enough to cut.

Experiments to test this expectation were started in 1938, 1939, and 1941 in alfalfa-clover-timothy meadows at the Trumbull County Experiment Farm. Another test started in 1942 badly winter-killed on all plots and was abandoned after 1 year. Cuttings included four different arrangements of dates. They were as follows:

(1) Plots 1 and 6, three cuttings each year, the first one early.
(2) Plots 2 and 7, two cuttings the first year and three cuttings the second year, the first one early.
(3) Plots 3 and 8, three cuttings each year, the first cutting made 2 weeks later then on plots 1 and 6.
(4) Plots 4 and 9, two cuttings both years.

The data in table 5 show that during every 2-year period top yields were secured on plots 3 and 8 which were cut three times. Cuttings on these plots started on June 15 and ended on September 10. However, this made a rather exacting schedule and one that would be difficult, or even impossible, to follow with a large acreage and a limited labor supply. This spacing of cuttings produced an average yield of over 7½ tons of hay per acre in 2 years, with a top yield of over 9 tons. The drouth year of 1941 was responsible for lowering the average to the 7½ tons level. Three cuttings, especially of second- and third-year alfalfa, will probably be satisfactory when the first cutting is actually made on June 15. However, if anything delays that cutting, it means that the third cutting also will be delayed. Repeated experience on this Farm shows that there is no more certain way to invite winter-killing of alfalfa than to make a late cutting of hay (fig. 6). One good rule, therefore, is to take three cuttings when the circumstances are right, but whenever the first cutting is delayed, to take only two.

Second from the top in average yield for the three 2-year periods are plots 4 and 9 which were cut only twice each year. Compared with the top yield they are down 2820 pounds per acre for the 2-year period. Actually, the decrease was 1800 pounds the first year and 1020 pounds the second year. This indicates that the alfalfa was in better shape the second year under the two-cutting system than under the three, and thus more promising for a third year of production if it is desired to maintain the meadow for another season. Experience on the Farm shows that the two cuttings were not spaced to best advantage in these experiments. It is safe to say that plots 4 and 9 would have made a higher yield of somewhat lower quality hay if both cuttings had been made a little later, thus giving each a chance for some additional growth. In practice, if the first cutting is made about June 25, the second cutting is not made until August 10 to 25, depending on the weather. This gives a long period after the last cutting for fall root storage.

Under farm conditions, where large meadow acreages are involved, haying is likely to last anywhere from 2 weeks to a month. On the Trumbull Farm the starting date is June 10, or even a few days earlier if a big harvest is in prospect. At this early date it is considered preferable to cut the second- or third-year meadows first so as to give the young alfalfa in first-year meadows a longer opportunity to store root reserves. Also, there is another important reason for cutting older meadows first, especially if they contain a considerable proportion of timothy. Early in June, when this grass is heading and before it blooms, it makes a palatable and nutritious hay, but when harvested 2 or 3 weeks later the resulting product is not nearly as acceptable in the dairy mow.

These older early-cut meadows may be cut once or twice more during the season. If the meadow is to be saved for another year the final cutting is made not later than September 10, but if it is to be plowed for corn the cutting or pasturing may be delayed as long as desired.

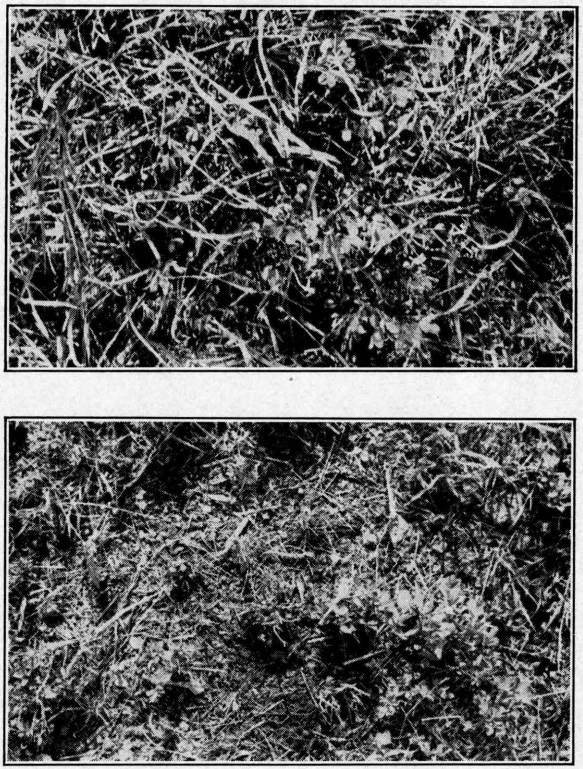

Fig. 6.—Late cutting results in heaving. Trumbull County Experiment Farm, May 8, 1935. Field 4, sown in 1932.

Upper—Last cutting August 31, 1934, not heaved.

Lower—Cut August 31, and again October 20, 1934, removing 1200 pounds of hay per acre, heaved and killed so completely that the field had to be plowed. This was typical of several late-cut fields on the Farm in the spring of 1935.

Cutting of first-year meadows begins not earlier than June 15. Ordinarily, only one other cutting is made because it takes quite an exacting schedule to permit a third cutting prior to September 10. Due to weather or to other contributing factors, such as labor supply, considerable hay (possibly even a third of the first cutting on the Trumbull Farm) is made after June 25. It is recognized that this later-cut hay is not of the highest quality but it is fed in liberal quantities and the cows have a chance of picking out the better parts and discarding the refuse.

Due to the fact that mows mostly are filled from the first cutting and that meadows are pastured extensively during the summer months, the hay making schedule on the Trumbull Farm is not as involved as the previous discussion might seem to indicate.

PLANNING FOR MINIMUM PASTURE DAMAGE

As far as possible, rotated meadows are pastured in rather definite manner so that damage may be held to a minimum. This requires some planning. One of the "musts" is not to punish too severely the meadows that are to remain for another year. Such meadows are not pastured during the critical period which begins about September 10 and continues until the alfalfa is well into the dormant stage. Judicious pasturing during this period when the roots are replenishing their winter reserves may be somewhat less dangerous than taking off a hay crop, but, on the other hand, a slight over-pasturing may lead to such winter-killing as will seriously reduce the value for hay and pasture the following year. Therefore, pasturing during this critical period should be confined to bluegrass and the meadows that are to be plowed the following spring. This requires that the herd be rotated throughout the summer over the two or three meadows available in such a manner that the ones destined for fall pasture may be free of livestock from about August 15 to September 10. With favorable weather, this meadow may be knee high or better when fall pasturing starts and thus will furnish feed for several weeks.

SUDAN GRASS

Thus far, rotation meadows at the Trumbull County Experiment Farm have been so satisfactory for summer pasture that no need has been felt for including special crops, such as Sudan grass, in the regular farm program. In seasons anywhere near normal these more costly crops are unnecessary, and in drouth seasons they are not as reliable as a reserve supply of hay or silage. Sudan grass, or any other special pasture crop put in as an emergency after the drouth has started, is likely to be a disappointment as a source of dry-weather pasture because drouths cannot be detected soon enough to permit proper soil preparation. Then too, it must be remembered that sooner or later drouths are broken by more or less generous rains. If these rains do not come until late in the summer they are too late for the special summer crop, but they very likely will cause a considerable spurt in the fall growth of alfalfa, clover, and timothy. This very thing happened in 1941. After the severe spring and early summer drouth, rains came in time to cause a vigorous September growth of meadows. Pasturing of this started on September 26 and continued for 32 days. Hay and silage feeding was discontinued and did not start again until October 28. During this period Sudan grass probably would have been nearly worthless, perhaps even dangerous (because of the tendency of this short, late growth to be high in hydrocyanic acid) but this fall meadow growth was safe and probably made up for the pasture which Sudan grass might have furnished a couple of months earlier. The fine October pasture furnished by these meadows enabled the cows to start the barn-feeding period in excellent condition and in high production.

NO BLOAT LOSSES AT TRUMBULL FARM

Bloat never has been a problem in pasturing rotation meadows at the Trumbull County Experiment Farm. Cups filled with a mixture of salt and bonemeal are attached to stanchions and the herd has access to these twice a day. For the most part, cows have to come to the barn for water and so are likely to drink rather infrequently. Some timothy usually is in the mixture, but not always. As mentioned before, the cows have access to bluegrass pastures at all times and evidently consume varying quantities of grass in different stages of maturity. Meadow pasturing in June starts on fairly well matured plants but after that the practice is to pasture wherever opportunity offers, regardless of maturity.

THE OLD AND THE NEW

For several years in its early history, the Trumbull County Experiment Farm was like other farms of the area which "always had a feed problem." It might be stretching the truth somewhat to say that "now it never has a feed problem," but, as a matter of fact, that is not far from true. Salt, bonemeal, some oil meal, and, in bad corn years, a reasonable amount of that grain are purchased but the change for the better in the farm business as a whole is so marked that one scarcely knows how to present the picture in words. Those who have known the farm in both eras may feel that full justice has not been done in describing the transition; others, who have not seen the farm at any time, may be prone to say that the comparison is overdrawn.

In Part II of this bulletin there will be found the results of a 3-year feeding test which show how well the Holstein herd reacted when faced with liberal summer pasture and unlimited mangers of hay. However, any test conducted with two comparable groups of dairy cows cannot tell the entire farm story. Too many other angles are involved. There are such items as crop yields, number of cows that can be carried, the amount of feed that has to be purchased, and labor of the operator (a highly important item).

Earlier tables and discussions have shown that previous to 1930 crops were yielding lower and feed nutrients produced on the rotated area were appreciably lower than has been the case since the Experiment Farm got into the swing of liberal meadow acreage and heavy hay production. Table 6 contains data from Cow Test Association records (which extend back without a break to 1924), from daily milk records, and from business records of the Farm. Several key indicators are used which make possible a quite accurate comparison between the two very distinct eras, one prior to 1930, and the other after 1940. In addition, the record for the single year 1942 is given because that is about the earliest date that the entire herd was included in all phases of the new plan in full operation. The number of cows for 1942 was reduced due to an outbreak of Bang's disease. The Farm carried a larger than average number of young cattle so the total farm load was heavy. The fact that considerable hay was sold shows that the farm was not stocked to capacity.

Obviously, a comparison of two eras this far apart must not be taken too literally. The cows are not the same and some may question whether they were not of better breeding during the latter period. This is not known, but the herd must have been a good one prior to 1930 or it would not have attained an average milk production of over 10,000 pounds per cow. Only moderate-priced bulls have been used since then, and the quality of the herd in the latter era probably was not much, if any, higher than it was in the former.

TABLE 6.—The old and the new in dairy farm management
Trumbull County Experiment Farm

	Average of 3 years		Late year under new method 1942†
	The old 1927–1929	The new 1940–1942	
Milking cows in herd	13.9	19	17.3
Annual production per cow, lb.			
Milk	10,694	11,570	12,568
Butterfat	368	382	425
Annual production per farm, lb.			
Milk	148,650	219,815	217,440
Butterfat	5,118	7,262	7,361
Grain fed per cow annually, lb.			
Corn and oats	1,791	1,604	1,543
Oil meals	976	312	308
Bran	807	199	185
Gluten feed	139	.....	.....
Total grain per cow annually	3,713	2,115	2,036
Grain fed annually to milking herd, T.			
Corn and oats	12.45	15.62	13.34
Oil meals	6.78	3.04	2.66
Bran	5.61	1.94	1.60
Gluten feed	.97	.....	.....
Total grain fed to herd annually, T.	25.81	20.6	17.6
Pounds milk per pound grain fed	2.9	5.3	6.2
Pounds grain per cwt. of milk	34.5	19.0	16.0
Approximate daily winter ration, lb.			
Corn silage	45	20	20
Hay	12	30§	30§
Hay purchased, T.	3	None	None
Hay sold, T.	None	16	22

*During part of this period part of the herd was fed a moderately heavy-grain ration.
†All of herd on so-called light-grain ration.
‡Largely linseed and cottonseed in earlier, soybean oil meal in later period.
§More than 30 pounds placed in mangers. Uneaten part used for bedding or for other livestock.

An item in table 6 is worthy of especial mention. Grain consumption *per cow* was materially lower during the more recent period when hay and pasture consumption were increased. This liberal hay and pasture consumption resulted in a 75 per cent reduction in the amount of protein concentrates purchased. It did not effect as large a saving in corn and oats. *Per cow*, the reduction in these two home-grown energy grains amounted to 14 per cent, but, because more cows could be carried during the latter period, the total corn and oats requirements of the *entire dairy* actually were increased. Complicating the problem is the fact that the acreage available for corn and oats had been decreased to provide extra meadow land. Better oats varieties and corn hybrids have helped to maintain grain production on this smaller acreage, and corn occasionally is purchased. This latter is not a serious matter because the picture as a whole is so much brighter than formerly that it is not dimmed much by the need to occasionally purchase some corn.

Without further discussion, table 6 is recommended in all sincerity as one which any dairyman well can study. Its comparisons between two eras contain the lessons which point to the trend which future dairy production methods very likely will take.

SUMMARY

1. The Trumbull County Experiment Farm in its early history was representative of an area where there usually was a feed problem.

2. Rotation meadows kept for more than one year now form the basis for a better system of dairy farming which is efficient in the use of labor and in feed production.

3. Excellent meadow yields are secured by a comparatively simple limestone-manure-phosphate fertility program.

4. At this farm, heavy-yielding meadows are considered more reliable and more important than the corn crop as a source of dairy feed.

5. The successful inclusion of such perennials as timothy, alfalfa, and Ladino clover in the meadow mixture makes it possible to secure second- and third-year meadows that may outyield first-year meadows by 50 to 75 per cent and reduce the unit cost of feed nutrients produced in the rotation as a whole.

6. The period during which dairy cows can rely on bluegrass as the sole source of pasture is not much over 6 weeks. Some years it is less.

7. Rotation meadows, provided there is a sufficient acreage, can fill the mows to overflowing and furnish excellent summer pasture for a period twice, or even three times, the length of the bluegrass period.

8. Dairy cows in lush rotation meadow pasture seem to relish some dry bluegrass every day.

9. A large meadow acreage on any given farm may require the pasturing of some of the first cutting.

10. Ladino clover is not the equal of alfalfa in providing pasture during dry summer weather but it is not so particular as regards limestone and drainage requirements.

11. Cutting meadows on this farm before June 10 or after September 10 is injurious to alfalfa. Second- or third-year meadows containing a considerable proportion of timothy with the alfalfa are best cut in early June.

12. Alfalfa-grass rotation meadows in sufficient acreage, largely, and perhaps entirely, eliminate the need for Sudan grass pasture.

13. Pasture dates should be planned so that rotation meadows, which are to be kept another year, can be free of livestock during the critical month or 6 weeks starting about September 10.

14. Bloat has caused no trouble on the Trumbull Farm where the cows have had access at all times to bluegrass pasture and where the meadow mixture has contained varying amounts of timothy.

15. The Trumbull County Experiment Farm buys less grain but carries 20 cows now more easily than it did 14 cows prior to 1930.

PART II. MILK PRODUCTION RESULTS

C. F. MONROE AND WALTER LIVEZEY

Every dairyman is vitally interested in reducing milk production costs. Accordingly, an experiment was conducted to determine the extent to which heavy feeding of good roughages would lower the grain requirements of dairy cows. This was a continuation of dairy feeding work previously conducted at the Trumbull County Experiment Farm.[1] In the 1934 report, the work covered principally the winter or barn-feeding season. It was shown that by feeding hay liberally a saving could be made in the feeding of grain without adversely affecting milk production. The hay used in the work was that grown on the farm and consisted principally of alfalfa-timothy-clover mixtures. During the summer, the grazing was limited to the permanent bluegrass pastures, with supplementary hay being fed in the barn.

In the present report, the work has been extended to include the grazing of the meadow crops in the summer, along with a maximum utilization of hay during the winter season. Experience on the farm showed that time and labor could be saved by allowing the cows to graze the meadows, at certain times, thereby harvesting the crops and feeding themselves at the same time. Such harvesting is independent of unfavorable curing conditions and, at the same time, provides a feed of high quality. When the acreage of hay to be made is large the assistance of the animals is welcome. One possible disadvantage in having the animals graze the meadows as compared to making hay is in a seemingly greater wastage from tramping. However, in making such a comparison, there is a tendency to assume that it would be possible to harvest the hay at the proper time without losses. Experience has shown that such ideal conditions are rare.

OBJECT OF EXPERIMENT

The primary object of this work was to compare the yearly milk productions obtained from moderately light and light grain feeding when meadow crops are used liberally both as hay and pasture.

PLAN OF EXPERIMENT

Two similar groups of Holstein cows were fed grain at two different levels. In all other respects the two groups were treated alike. In fact, they were handled as one herd. The plan called for feeding grain according to a schedule, as shown in table 1. According to this schedule one group was to be fed grain at a straight ratio of 1 pound of grain to every 4 pounds of milk produced, and 2 pounds of grain daily during the dry period. This is a rate of grain feeding often recommended for practical feeding and is designated in this work as "moderate-grain feeding." The other group was to be fed grain at a lower rate and according to a different system. The cows of this group were to be fed grain at the rate of 1 pound of grain to every 3 pounds of milk

[1]This work was reported in Bulletin 538, "Alfalfa-Timothy Hay for the Dairy Farm," published in 1934 by the Ohio Agricultural Experiment Station.

produced above 20 pounds daily. When producing under 20 pounds of milk daily and throughout the dry period this group was to receive no grain. By this method, grain is fed at ratios varying from a 1 to 5, when the cow is producing 50 pounds of milk per day to a ratio of 1 to 20 or 22, when the production is at 20 or 22 pounds daily. This rate is designated as "light-grain feeding."

TABLE 1.—Grain feeding schedules based on daily milk production

Moderate-grain group Approximately 1 pound of grain to 4 pounds milk		Light-grain group Approximately 1 pound of grain to 3 pounds of milk, above 20 pounds	
Milk production per day	Grain to feed per day	Milk production per day	Grain to feed per day
Lb.	*Lb.*	*Lb.*	*Lb.*
50–46	12*	50–48	10*
45–42	11	47–44	9
41–38	10	43–41	8
37–34	9	40–38	7
33–30	8	37–35	6
29–26	7	34–32	5
25–22	6	31–29	4
21–18	5	28–26	3
17–14	4	25–23	2
13–10	3	22–20	1
9– 6	2	19– 0	0
5– 0	2		
Dry period	2	Dry period	0

*Top limit on grain feeding, regardless of amount of milk produced.

Upper limits were placed on the amounts of grain fed daily to individual cows. Thus, regardless of the amount of milk produced, a cow in the moderate-grain group could not receive more than 12 pounds of grain daily and one in the light-grain group, 10 pounds. At the beginning of lactation the grain was increased very gradually, until the upper limits were reached. This restricted method of feeding lowered the total grain intake in both groups. In addition to this, the amounts of grain consumed when the cows were on pasture were often less than are indicated in the schedules. These conditions have had an effect on the total amounts of grain which the cows ate in this comparison, but these same conditions are frequently encountered in practical feeding.

Grain Mixture

The grain mixture used throughout this work was a fairly simple one containing four ingredients and averaging around 14 per cent total protein. It consisted of 77.5 per cent of the farm-grown grains corn and oats, 12.5 per cent wheat bran, and 10 per cent soybean oil meal, with the addition of 10

TABLE 2.—Grain mixture used

	Lb.
Corn-and-cob meal	425
Ground oats	350
Wheat bran	125
Soybean oil meal (41 per cent)	100
*Salt	10
Total	1010
Total protein of mixture, 14 5 per cent	

*A mixture of equal parts of steamed bonemeal and salt was placed in salt cups attached to the stanchion divisions.

pounds of salt to each 1000 pounds of mix. The formula for the mixture is given in table 2. The use of the term "grain" hereafter used in this report refers to the mixture as listed in table 2.

Roughage Feeding

Corn Silage Feeding.—In order to obtain the maximum consumption of hay, the corn silage was limited to 20 pounds daily for each cow. This is about one-half the amount of silage ordinarily fed to Holstein cows similar to those used in this work. The amount of corn silage fed was estimated according to the size of the forkful, with frequent check-weights being taken. It was found that corn silage could be fed fairly accurately in this manner by a careful feeder. The silage was made from well-eared corn of a grain variety, generally cut fairly late. In general, the quality of corn silage fed throughout this work was very satisfactory and the cows ate it eagerly.

Hay Feeding.—The plan followed in feeding the hay was to give the cows all that they cared to eat. In order to be sure of doing this, an excess was fed and the refuse was weighed back. One day each week an estimation of the amount of hay eaten was obtained by weighing all the hay fed and that refused for each group of cows. For the remaining days of the week, the hay was fed in as nearly as possible the same manner as on the weigh-day. By this system the cows received all the hay they cared to eat, with a weighed record being taken one day a week.

The hay fed was that grown on the farm and stored in the mow directly over the stable as uncut loose hay. Like any hay which is cured naturally, the quality varied according to the weather conditions. However, every attempt was made to have good hay by cutting it when the legumes were in the early-bloom stage when possible and by curing it in the windrow. This hay was a mixture of alfalfa, timothy, and clover, with the legumes forming the larger part. Considerable variation in the kinds of hay fed was to be expected since the plan called for utilizing the hay grown on various fields over a period of three seasons. In general, clover tended to predominate in the first cutting of the first-year meadows, while timothy made up a considerable portion of the alfalfa-timothy mixture in the first cuttings of the second and third year meadows. Second cuttings of any year were largely alfalfa. When possible, these different kinds were fed as different feedings on the same day. When this was not possible, the different hays were fed as they were encountered in the mow.

TABLE 3.—Protein analyses of hays

No. of samples	Description of hay	Average protein	Range	
			Low	High
		Pct.	*Pct.*	*Pct.*
2	Practically pure alfalfa (2nd cutting)	13.94	.....	.....
13	Alfalfa-clover-timothy	11.74	7.44	14.06
17	Clover and timothy	11.30	7.66	13.94
24	Alfalfa and timothy	10.76	8.00	14.44
15	Practically pure timothy	7.70	4.74	9.75
	Refuse hay*			
6	Medium-grain group	12.60	8.31	16.25
6	Light-grain group	10.50	3.66	13.44

*The character of the refuse material varied from mostly leaves and fine material to coarse stems. This is reflected in the protein analyses.

The protein analyses of the various kinds of hay as fed are given in table 3. In general, this hay was only moderately high in protein, averaging around 10 per cent. It should be emphasized that the hay used in this work was that grown and made on the farm and was not a specially selected standardized hay.

The protein analyses of the hay refused by both groups of cows is also given in table 3. There were six pairs of such analyses, representing the refuse from the same feedings to each group. The refuse from the medium-grain group contained slightly more protein than that from the low-grain group. This was true in five of the six comparable samples. The character of the refuse, especially in respect to amounts of leaves, varied widely between the samples as may be judged by the wide range in protein content. Although it is entirely possible that the rate of grain feeding could have influenced the tastes of the cows, the evidence as given above is not sufficient to justify such a statement.

Pasture

Each year the cows were started on permanent bluegrass pastures the fore part of May. These pastures had been improved by liming and fertilizing. They were mowed one or more times during the season. The cows grazed these pastures as their only source of roughage for 5 to 6 weeks, when they were then given access to some rotation meadows along with the permanent pastures. This practice was continued for the remainder of the season.

This plan of grazing the two differnt types of pastures was easily accomplished on this farm since the permanent pastures extended for almost the entire length of one side of the farm. The meadows were enclosed temporarily for grazing purposes by means of an electric fence. Experience in giving the herd this opportunity of choice showed that the cows spent considerable time on the bluegrass, although they had available an abundance of meadow forage. No trouble with bloat was encountered in this work. There is no means of knowing whether the bluegrass aided in preventing bloat.

Division of Herd into Groups

When the trial was started, the available cows were arranged in pairs as nearly equal as possible, according to age, stage of lactation, and milk-producing ability. Then one of each pair was assigned to a group. As heifers freshened, they were added, in rotation, to the groups. The individual cows were not reversed but were fed continuously throughout the work as they were started. For calculating the results, lactation periods considered to be normal have been used rather than the yearly productions of the groups which may have included parts of two lactations. With the exception of a few lactations in each group which were started shortly before the experimental feeding was begun, this work represents complete lactation periods.

Management of Cows

The general care given the herd was much the same as the ordinary practical dairyman would give his cows. During the winter, the cows were kept in stanchion stalls provided with drinking and salt cups. The cows were turned out once each day for exercise when the weather permitted. Grain and corn silage were fed two times per day. Hay was generally fed three times per day, the third feeding being made the last thing at night or about 9 P. M.

Milking

All the cows were milked twice daily by a milking machine, with a special attempt being made to limit to 5 minutes[2] the time the machine was left on any cow. A strip-cup was used on each cow just previous to milking, and each cow was stripped by hand after the removal of the machine. During part of the work the teat cups were dipped in rinse and chlorine solutions between cows. From an experimental viewpoint the uniformity of the milking and the satisfactory way it was performed have been important features of this work.[3]

RESULTS

Yearly Production of Milk and Butterfat

The comparison of the total average productions on the two levels of grain feeding is shown in table 4. For this comparison the data have been adjusted to a yearly, or 365-day, basis. The cows freshened at approximately yearly intervals. The sum of the actual number of days in milk and the number of days dry amounted to approximately 365 days for each group, with each group showing the same proportion of milking to dry days.

The summary represents the averages of 22 lactation periods on the moderate-grain feeding and 21 on the light-grain feeding, from 10 and 11 different cows, respectively, in each group. The work extended over a space of 3 years. During this time there were nine cows that completed three lactation periods, four completed two periods, and eight, one period. The distribution of these was approximately the same in the two groups.

The production converted to a yearly interval is based on 290 days' lactation for the moderate-grain feeding and 289 days for the light-grain feeding. This difference of one day may be disregarded for all practical purposes. In this time, which represents the year's production, the higher level of grain feeding resulted in an average production per cow of 10,425 pounds of milk and 343.0 pounds of buterfat, whereas the lower level of grain feeding gave 10,693.0 pounds of milk and 344.8 pounds of fat. This difference of 267.8 pounds of milk and 1.8 pounds of butterfat in favor of the light-grain feeding is not significant and does not represent a recognized advantage for the light-grain feeding. When the milk and butterfat productions are combined into one figure, as represnted by 4 per cent milk (F. C. M.) which expresses the energy output in milk production, the difference amounts to 134 pounds. This is a difference of less than 1½ per cent.

The butterfat tests were comparatively low in both groups, the cows being naturally low testers. On the heavier rate of grain feeding the average test was 0.07 per cent higher than on the lighter grain feeding. Here again the difference is very slight.

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[2]Five-minute milking is considered desirable according to A. C. Dahlberg in New York State Agricultural Experiment Station Bulletin 654, July 1935. Recommendation was substantiated by the same investigator in Bulletin 697 of that Station.

Four-, 5-, or 6-minute milking is recommended by C. A. Matthews, J. M. Shaw, and Earl Weaver in Iowa Station Bulletin 248, 1928.

Note: Some of these cows milked out in much less time than 5 minutes and the machine was taken off.

[3]For this the authors are grateful to Mr. Harold Weber, who did most of the milking throughout the work.

Feed Consumption

Grain.—The amounts of feed, as given in table 4, apply to the intakes for the entire year, which includes the dry as well as the milking period. On this basis, the moderate-grain group consumed 2,442 pounds of grain and the light-grain group, 1,639 pounds, or a difference of 803 pounds. In considering these figures for grain consumption, the method of allotting the grain should be kept in mind. In the final analysis, this work not only represents a study of two levels of grain feeding but also two methods of grain feeding. Thus, it was planned to feed the higher level at the ratio of 1 to 4 throughout the time of milk production and 2 pounds daily per cow throughout the dry period. Of the yearly consumption of grain of 2442 pounds, 150 pounds were fed during the dry period, leaving 2292 pounds fed during the lactation; this gives a ratio of 1 pound of grain to every 4.55 pounds of milk produced. This may be considered as truly "moderate grain feeding" and by some, even light feeding.

TABLE 4.—Summary—Comparison of production, feed consumption, and utilization of feeds for moderate- and light-grain feeding (converted to a yearly basis)

	Moderate-grain	Light-grain	Difference
Total lactations, no.	22	21	+1
Cows, no	10	11	−1
Days milked per year	290.0	289.0	+1
Days dry per year	75.0	76.0	−1.0
Average production:			
Milk, lb.	10,425.2	10,693.0	−267.8
Butterfat, percentage	3.29	3.22	+0.07
Butterfat, lb.	343.0	344.8	−1.8
4 per cent milk*, lb.	9,315.1	9,449.2	−134.1
Total feed consumption:			
Grain, lb.	2,442	1,639	+803
Hay, lb	5,762	6,235	−473
Corn silage, lb.	4,539	4,487	+52
Pasture, days	138	129	+9
Feed required per 100 pounds of 4 per cent milk*:			
Grain, lb.	26.2	17.3	+8.9
Hay, lb	61.9	66.0	−4.1
Corn silage, lb.	48.7	47.5	+1.2
Pasture, days	1.5	1.4	+0.1

*4 per cent milk=0.4 × pounds of milk added to 15 × pounds of butterfat.

On the other hand, all the grain consumed by the light-grain group was fed during the milking period and that part of the period when the production exceeded 20 pounds per day. On the average, these cows received no grain during the last 4 weeks of their lactation. The ratio of grain to total milk production for the lactation was 1 to 6.52; with the last 4 weeks excluded, it amounted to 1 to 6.30. As previously described, the grain was fed to this group at the rate of 1 pound to every 3 pounds of milk produced in excess of 20 pounds daily. By such a method of apportioning grain, there is a continual change in the ratio of grain fed to milk produced.

Hay.—Hay was fed in excess of the amount eaten; hence, the weights of hay given in table 4 for the amounts actually eaten may be considered as a measure of the cows' capacity for hay under the conditions prevailing. Thus, the moderate-grain group ate 5,762 pounds; whereas, the light-grain group ate 6,235 pounds, or 473 pounds more. With the exception of small amounts of hay fed late in the pasture season, all the hay was fed during the barn feeding period.

Corn silage.—Since all the cows were fed corn silage at the uniform rate of 20 pounds per day during the barn-feeding period, the average total intake of both groups should be nearly the same. This proved to be the case, each group consuming approximately 4,500 pounds of silage. Also, a small amount of silage was fed near the end of the pasture season. The cows were eager to get the silage and readily ate the amounts offered. Observing the behavior of the cows when the silage was being fed would lead one to believe that the feeding of this roughage provided a desirable variety.

Pasture days.—The feed intake from grazing has been expressed in terms of pasture-days. This includes the time spent on both the permanent bluegrass pasture and also on the meadow-crop fields in conjunction with bluegrass. As here used, the term "pasture-days" applies to the days that the cows received all or practically all of their roughage intake from grazing.[4] Obviously, this term does not show the actual quantitative intake from grazing or any difference between the groups in this respect. Both groups were pastured together as one herd and given an equal opportunity. The small difference of 9 days in the number of pasture-days, as shown in table 4, is the result of slight differences in the dates that the individual cows were started on the experiment. The herd was on pasture for a little less than 5 months of each year.

Other Comparisons

In addition to the comparison of the yearly averages for the two groups, as shown in table 4 and just described, several other comparisons may be made. These comparisons are of help in evaluating the averages shown in table 4.

Hay consumption.—One of the important features of this work was the liberal feeding of hay in the barn during the winter season. According to the figures for hay consumption given in table 4, the light-grain group ate a little more hay than did the moderate-grain group. This difference existed in all 3 years throughout the work.

TABLE 5.—Hay fed and refused during the barn-feeding seasons—per cow daily

	1938-1939		1939-1940		1940-1941	
	Moderate-grain	Light-grain	Moderate-grain	Light-grain	Moderate-grain	Light-grain
Hay fed, lb	34.95	38.96	37.55	38.37	31.47	32.21
Hay refused, lb	8.80	9.26	8.18	7.26	4.21	3.84
Hay eaten, lb	26.15	29.70	29.37	31.11	27.26	28.37
Refuse, per cent	25.20	23.80	21.80	18.90	13.40	11.90

A study of the average daily intakes of hay, together with the amounts fed and refused, is presented in table 5. In the 3 years, the average hay consumption for the light-grain group varied from 28 to 31 pounds per day and that of the moderate-grain group, from 26 to 29 pounds. The amounts of hay refused each day averaged from 4 to 9 pounds, approximately.

[4]The cows were on pasture additional days when they received some hay and silage in the barn; these are not counted as "pasture days."

Comparison of productions by weeks.—The productions in terms of 4 per cent milk on the two levels of grain feeding are charted in figure 1, by weekly intervals, for the first 36 weeks of lactation. This analysis indicates that the two groups performed very nearly alike throughout the period covered. Of special interest, is the fact that the light-grain group maintained production in the latter part of the period fully as well as the moderate-grain group. Included in this graph are the productions of all the cows, the same as shown in table 4.

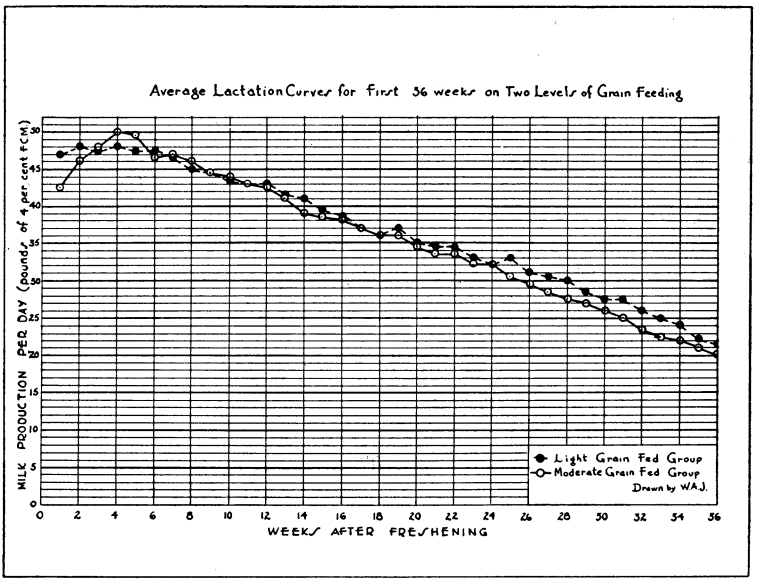

Fig. 1.—Productions in terms of 4 per cent milk for the cows on the two different levels of grain feeding.

A comparison of productions during the first 8 weeks.—An important difference in the feeding of the grain to the two groups came near the close of the lactation period and during the dry period. The light-grain group received no grain for an average of 31 days at the close of the lactation and for the dry period (which averaged 76 days). Thus, for 107 days previous to freshening, these cows had received no grain, although when corn silage was fed they received grain in the silage. Did this lack of grain have an effect on the condition of the cows or lower their production during the fore part of the succeeding lactation?

In answer, the moderate-grain group may be used as a basis of comparison. Although this group was not fed heavily on grain at these times, they did receive some grain at all times. There was no difference in the physical appearance and condition of the two groups that consistently favored either group. There also appeared to be no marked difference between the two groups in their milk production during the early part of the following lactations. This is shown in table 6, in which the daily productions of the two groups are given for the first 8 weeks.

For this study, only those lactations of the second and third years of the work have been considered, those of the first year being omitted, since these were not preceded by the experimental feeding. According to the figures given in table 6, the light-grain group produced at a slightly higher rate than the moderate-grain group. This may have been a matter of the individuality of the cows and should not be interpreted to mean that withholding grain during the dry period increased production. However, it is significant that these cows averaged over 50 pounds of milk per day for the first 8 weeks of lactation, as did the cows fed grain previous to freshening. Such a production may be considered a near-maximum for cows on two-time-a-day milking.

TABLE 6.—Average daily production of milk—first 8 weeks of lactation

Average daily production of milk for—	Moderate-grain group (11 lacts.)	Light-grain group (9 lacts.)
First week, lb.	43.6	50.3
Second week, lb.	47.9	54.9
Third week, lb.	50.4	54.7
Fourth week, lb.	53.2	55.1
Fifth week, lb.	52.8	55.5
Sixth week, lb.	50.9	56.5
Seventh week, lb.	51.7	56.9
Eighth week, lb.	51.7	55.1

Effect of pasture.—In comparing the productions obtained from the two different rates of grain feeding, the question may be raised regarding the effect of pasture. It is possible in a trial such as this that one of the groups may have had an advantage from the pasture, due to a difference in the time of freshening. This could be true regardless of the fact that both groups were pastured together and had approximately the same number of total pasture days. That the groups were fairly evenly balanced in respect to season of freshening is shown in table 7.

TABLE 7.—Seasons of freshening

Season	Moderate-grain group	Light-grain group
	No.	*No.*
Winter	3	3
Spring	9	6
Summer	2	1
Fall	8	11
Total	22	21

The chief difference between the groups was that there were three more fall-freshenings in the light-grain group than in the moderate-grain group, with the reverse being true for spring freshenings. Thus, the light-grain group spent a slightly greater proportion of its flush milking period, involving heavier grain feeding, under barn conditions than did the moderate-grain group and actually obtained less advantage from the ample grazing available than did the moderate-grain group.

The meadow-crop pastures have been considered as a replacement for hay during the summer. Just as the cows were fed hay in excess during the winter, they were also provided with adequate grazing throughout the summer. However, it must be admitted that the adequacy of grazing is not as readily determined as is the feeding of hay in the barn where the amounts eaten may be determined. By the use of meadow crops it was possible to have grazing available for the cows throughout the summer, especially during July and August when little grazing was afforded by the permanent bluegrass pastures. A rapid decline in production is frequently encountered during this midsummer season unless special attention is given to providing extra roughage, either as hay or as supplementary pastures such as was provided in this work.

For studying the effects of the supplementary pastures on the productions of the two groups, the records of the spring-freshening cows during the summer periods have been compared; these records were then, in turn, compared to the records made by the fall-freshening cows during comparable periods in lactations under barn-feeding conditions. These comparisons are shown in table 8. The productions are shown on a percentage basis, with the June production and a similar period in the lactations for the barn-feeding season being taken as 100 per cent.

TABLE 8.—Percentage production on pasture and on barn feeding during the winter. (June=100 per cent)

(Using similar periods in the lactations)

4-week periods* on pasture	On medium-grain	On light-grain
	Pct.	*Pct.*
June	100	100
July	92.4	92.9
August	88.7	87.3
4-week periods* on winter barn-feeding (Taken at same stages in lactations as above)		
To compare with June	100	100
To compare with July	89.5	90.0
To compare with August	88.6	86.6

*At the start of the first 4-week period the cows in the medium-grain group averaged in the tenth week of lactation and the light-grain group in the thirteenth week.

Table 8 indicates that there was very little difference in the rate of decline between the two groups either under grazing or barn-feeding conditions. The very small differences favoring the medium group cannot be shown to be significant. As indicated in the footnote, this group was not quite as far advanced in the lactation period as the light-grain group. Furthermore, in both groups there was slightly less decline during the summer season than for a comparable period in the lactations on barn feeding during the winter. The cows were averaging approximately 1400 pounds of milk for the 4-week periods in June and 1250 for the comparable periods under barn feeding.

Liveweights.—During the first 18 months of this work, all the cows were weighed once a month. It then became necessary to discontinue this phase of the work because of a shortage in help; hence the information on the liveweights is not as complete as is desired.

In table 9, the average liveweights for the two groups have been arranged on a lactation basis. The weights, as presented in this table, represent the averages of three spring and three fall freshening cows in each group. This grouping was made in order to balance the effect of seasons.

TABLE 9.—Liveweights, by months, following calving

Average per cow*

	Moderate-grain group	Gain + Loss —	Light-grain group	Gain + Loss —
Month	*Lb.*	*Lb.*	*Lb.*	*Lb.*
1	1248	.....	1272	.....
2	1234	—14	1271	— 1
3	1227	— 7	1265	— 6
4	1279	+52	1263	— 2
5	1301	+22	1259	— 4
6	1292	— 9	1280	+21
7	1298	+ 6	1285	+ 5
8	1271	—27	1322	+37
9	1326	+55	1324	+ 2
10	1368	+42	1337	+13
Before freshening	1384	+16	1428	+91
Average weight during lactation	1284	.....	1287	.....
Total gain during lactation	.....	120	.....	65
Total gain during year	.....	136	.....	156

*Six cows in each group, consisting of three spring- and three fall-freshening cows.

According to the weights shown in table 9, the moderate-grain group made almost twice the gain during the lactation that the light-grain group made. The greatest consistent difference between the two groups came in the ninth and tenth months of lactation; the moderate-grain group averaged 97 pounds of gain as compared to 15 pounds for the light-grain group. During the dry period the situation was reversed, with the moderate-grain group averaging 16 pounds as compared to 91 pounds for the light-grain group.

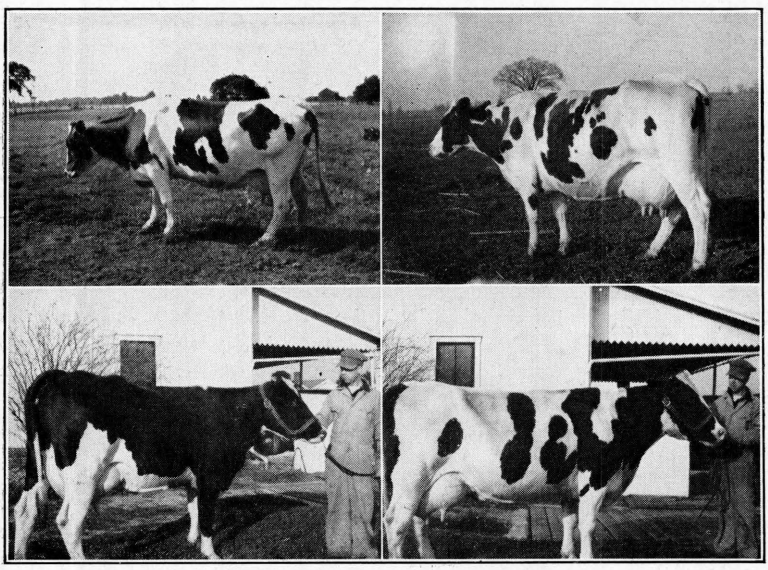

Fig. 2.—Left—Cows from the moderate-grain group. Right—Cows from the light-grain group. It will be noted that there was no difference in the physical appearance of the two groups.

The data on the liveweights confirm, in general, the impressions obtained from observing the physical appearance of the cows. There appeared to be no marked difference between the groups in the amount of flesh that they were carrying. Neither group seemed to be especially thin nor did they appear to be carrying any extra fat during the milking period. Toward the end of the lactation and during the dry period, the cows appeared to flesh up but they did not become excessively fat.

Reproduction.—The history of reproduction in both groups was satisfactory, and there is no evidence that the difference in the levels of grain feeding affected reproduction. The data for this phase of the trial are shown in table 10.

TABLE 10.—Reproduction, services required, and birthweight of calves

	Moderate-grain group	Light-grain group
Freshenings, no.	19	18
Total services required, no.	28	32
Services per conception, no.	1.42	1.78
Conceptions to first service, no.	14	10
Conceptions to first or second service, no.	16	15
Birthweight of calves:		
Male, lb	98.7	93.9
Female, lb	94.4	94.6

The number of services required per conception was very slightly higher and the conceptions to the first services lower in the light-grain group. It is very questionable if this is of significance. In both groups over 80 per cent of the conceptions occurred to the first or second breeding. There were three cases in each group in which the cow had to be bred more than twice.

The birthweights of the calves were approximately the same in the two groups. There appeared to be no outstanding differences between the calves born to the two groups in respect to the health and vigor.

DISCUSSION

This work represents an attempt to utilize the maximum quantity of meadow crops in feeding the dairy herd. To be satisfactory such a program should maintain a reasonable production and also keep the animals in a normal state of health. Two different levels of grain feeding have been used in connection with this liberal use of meadow crops. Presumably, an increase in grain feeding would lower, within certain limits, the intake of hay. Although the differences in the amounts of grain fed in this trial were not large, it is reasonable to suppose that, if the cows had been underfed at the low levels of grain used, a small increase in grain feeding would show a significant increase in milk production. The fact that the moderate-grain group did not produce more milk than the light-grain group would indicate that the latter group was being adequately fed on the liberal roughage intake. In fact, the satisfactory performance of both groups indicates that a reasonable production may be expected with a liberal use of meadow crops and a light or moderately light rate of grain feeding as represented in this trial.

RESULTS OBTAINED AT OTHER EXPERIMENT STATIONS

The reports (5) (1) of an experiment conducted at the Huntley Field Station in Montana show that cows fed a limited amount of grain averaged 94 per cent as much milk as those fed a full amount of grain. The rates of grain feeding were 1 to 6 for the limited- and 1 to 3 for the full-grain feeding. The cows were given adequate amounts of alfalfa hay, along with corn silage and some beets during the barn-feeding season. They were on good pasture for 164 days of the year. These animals were milked three times per day, which may have favored the heavier-grain feeding.

At the Tennessee Station (7), full- and half-grain feeding were compared on a yearly basis, using Jersey cows. The rates of grain feeding compared were 1 to 3 and 1 to 6. The results obtained in 4 years' work on this comparison showed that the cows on the limited amounts of grain produced 97.5 per cent of the amount of 4 per cent milk produced by the full-grain-fed group. In this work, liberal amounts of roughages were fed, and the limited-grain group was given the opportunity of getting additional roughage in the winter from pasture whereas the full-grain group was kept in the barn.

In a special study (3) made by the United States Department of Agriculture on "Input-Output Relationships in Milk Production," a reduction in grain feeding similar to the light-grain feeding in the present report resulted in a 93 per cent production of 4 per cent milk. The pasturage obtained by the cows amounted to about "the equivalent of 2.5 months' grazing on first class pasture." A separate account in the report is given of the results obtained at the Virginia Station, where the cows were on pasture a full 6 months "and the pastures were good virtually all the time." An average production of 9253 pounds of 4 per cent milk was obtained with 2076 pounds of grain. This was calculated as 96 per cent of the "basic producing ability of the cows."

At the Louisiana Station (4), limited-grain feeding (1 : 6) gave a 90 per cent and better production as compared to full-grain feeding (1 : 4) at 100 per cent. In this work "optimum grazing was not always available." The following significant statement regarding pasture is contained in the report: "Every pasture test with which the author is familiar has shown the stimulating effect of fresh pasture over close grazing or dry feeding."

Trials conducted at the Utah Experiment Station by the United States Bureau of Dairying resulted in an 83 per cent production of 4 per cent milk on limited-grain (1 : 6) as compared to full-grain feeding (1 : 4). The authors themselves point out that these results do not agree with those obtained in the Huntley experiment (1, 5). They point out that the cows on the limited-grain feeding in the Utah work received no corn silage and that the grain ration consisted of barley only. Whereas in the Huntley work corn silage and a grain mixture were fed. Likewise, the full grain-fed group in the Utah trial received corn silage and a mixture of grains.

The results of these other trials just described indicate that a fairly satisfactory production was obtained with limited-grain feeding (1 : 6). Such feeding resulted in 90 per cent or more of the normal production obtained from full-grain feeding (1 : 3 or 1 : 4). Save for minor exceptions, roughages of good quality and ample grazing were supplied. The results obtained in the trial herein reported are in general agreement with the findings from other Stations. The fact that in this work no difference in production was obtained

from the two levels of grain feeding is not absolute proof that a small difference could not have existed. In an experiment such as this, covering an extended period of time where the cows are not reversed, a difference in the producing ability of the cows could favor one ration over the other. For instance, it is entirely possible that the cows in the light-grain group were slightly better producers than those in the moderate-grain group or some of these cows could have had exceptionally "good years." A difference of 5 per cent could have been thus concealed by a difference in the producing ability of the groups.

In the experiments, the results of which have been reviewed, there were certain details in which the trials differed from each other. Likewise, in the trial reported in this bulletin, there were certain features in which this one has differed from the others. These features, although covered in the description of the work, call for special consideration. They may have had an effect on the experimental results, although there is no means of proving this from the data. By the same reasoning, it seems probable that these features may have an application in practical feeding.

SPECIAL FEATURES OF THIS EXPERIMENT

1.—*Type of meadow crop used.*—The advantages of growing the alfalfa-timothy-clover mixtures have been enumerated in the fore part of this bulletin. The experience gained after several years of feeding these mixtures indicates that the cows relish this type of hay and it seems to satisfy them. In addition to the variety offered in feeding the mixed hay, some clover hay from the first-year meadows and some second-cutting hay, containing chiefly alfalfa, contributed further variety.

Very distinctly, this work is based on feeding legume-mixed hays such as are grown on the farm and fed much as any practical dairyman would be forced to do. This is in contrast to feeding a straight alfalfa hay, even of excellent uniform quality, throughout an experiment.

This mixture seemed to provide a very satisfactory pasture, giving a desirable variety. In addition, the cows were allowed to graze the permanent bluegrass pastures at will. There was no trouble with bloat and milk production was maintained satisfactorily during the summer months.

2. *Liberal use of hay and meadow crop pastures.*—Hay was fed in excess of what the cows would clean up and was kept before them practically all the time. This was fed three times per day with the excess removed each time. In this way, the cows were allowed to choose the better portions and to eat up to their capacity. In order to encourage a heavy consumption of hay the corn-silage feeding was limited to moderate amounts (20 pounds daily per cow).

During the pasture season, ample amounts of meadow crops were made available for grazing. The cows were not compelled to graze closely, even though at times this may have appeared wasteful.

3.—*Well-eared corn used for silage.*—Although only small amounts of corn silage were fed, this silage was of good quality, having been made from well-eared corn. Since such silage may contain 40 to 50 per cent of its dry weight as ears, the cows received some additional grain from the silage. Part of the time the silage supplied the only grain received by the light-grain group.

At feeding time, the cows were eager to receive their silage and it would seem that the silage added a desirable variety and acted as an "appetizer" for the hay.

4.—*Method of apportioning grain to the light-grain group.*—On the lower level of grain feeding, grain was fed at approximately the rate of 1 pound to every 3 pounds of milk produced in excess of 20 pounds daily. Below this production, and during the dry period, no grain was fed to the cows in this group. This principle of allotting grain has been devised by Woodward, Shepherd, and Graves (6), of the Bureau of Dairy Industry, for feeding with silage and liberal amounts of good-quality hay. This system of feeding is claimed to supply the needed nutrients in a more accurate manner than the straight ratio basis of allotting grain. The rates of feeding used here were slightly lower than the recommendation of the originators, who suggested feeding 0.4 pound of grain for each pound of milk (1.2 to 3) above 16 pounds of milk produced daily.

Another variation in grain feeding was made by placing a "ceiling" on the amount of grain fed; even this ceiling was attained gradually following freshening. This, together with the fact that the cows did not eat grain up to their quotas (at times) when they were on good pastures, reduced the grain intake of both groups below the theoretical intakes.

5.—*Mineral supplement fed.*—As an insurance against the possibility of a phosphorus deficiency and to give a better calcium-to-phosphorus ratio in the feeding, a phosphorus-containing supplement, in the form of either steamed bonemeal or dicalcium phosphate was offered free-choice. This was done by mixing the mineral with an equal weight of salt and placing the mixture in salt cups attached to the stall divisions. With animals fed a small amount of grain, or as in the case of the light-grain group in this work where no grain was fed for part of the time, the use of a phosphorus-containing mineral supplement would seem to be a good precautionary measure. For the purpose of supplying phosphorus the grain mixture used in this work contained 12.5 per cent wheat bran. There was no evidence of a phosphorus deficiency occurring in this work.

SUMMARY

Two levels of grain feeding have been compared under farm conditions over a 3-year period with a herd of purebred Holstein cows. One group consumed 1 pound of grain for every 4.5 pounds of milk produced daily and 2 pounds of grain daily throughout the dry period; whereas, a similar group of cows was fed grain at the rate of 1 pound to every 3 pounds of milk produced daily over 20 pounds. Under a daily production of 20 pounds and throughout the dry period, these latter cows received no grain. This group averaged 1 pound of grain to every 6.5 pounds of milk produced. Other than the rate of grain feeding, both groups were fed and treated alike. All cows received all the alfalfa-timothy-clover mixed hay, together with some clover and alfalfa hay, that they cared to eat, an excess being fed. Corn silage was limited to 20 pounds daily per cow during the barn-feeding period. In the pasture season the cows were on an improved bluegrass pasture for the fore part of the season and then allowed access to the alfalfa-mixed meadows, in conjunction with the bluegrass pastures, for the remainder of the season. To insure against a possible phosphorus deficiency, either steamed bonemeal or dicalcium phosphate mixed with salt was offered free-choice in salt cups attached to the stall divisions.

No marked differences in the health, reproductive history, or production performance of the two groups were observed. Both groups appeared to be normal in all respects.

On a 365-day basis (which includes the dry period) the moderate-grain group produced 10,425.2 pounds of milk and 343 pounds of butterfat as compared to 10,693.0 pounds of milk and 344.8 pounds of fat produced by the light-grain group. The differences in production are not significant. The production of 4 per cent (F. C. M.) milk was 9,315.1 pounds and 9,449.2 pounds for the moderate- and light-grain feeding, respectively.

The curves of lactation for the two groups were approximately similar, indicating that the persistency of the light-grain group had not been adversely affected.

A limited study of the liveweights indicated that the moderate-grain feeding maintained the weights of the cows a little better during lactation than the lighter-grain feeding. The difference was not great and neither were the losses on the lighter grain feeding excessive. The latter group was able to make up this difference during the dry period.

There was practically no difference in the average butterfat test on the two levels of grain feeding.

The grain intake per year averaged 2,442 pounds on the higher level, and, 1,639 pounds on the lower level of feeding.

The moderate-grain group consumed 5,762 pounds of hay and the light-grain group, 5,235 pounds. The average daily consumption of hay was lower in each of the three barn-feeding seasons on the higher grain intake, averaging 27.6 pounds per day as compared to 29.7 pounds on the lighter grain feeding.

Corn silage was fed at the uniform rate of 20 pounds for each cow daily during the barn-feeding season. The average intake per cow in each group amounted to approximately 4500 pounds.

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